New Satellite Energy Balance and Water Cycle Products for the Study of Interactions between Atmospheric Hydrology and the Earth's Radiation Budget

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Project Hypothesis: This project will provide energy budget and hydrologic cycle datasets from the observations of TRMM, Aqua, and CloudSat, and, through their subsequent analysis, yield insights into the fundamental relationships between radiation, clouds, and precipitation on scales ranging from the mesoscale to those representative of global circulations.

Abstract

The objective of this research is to use complementary information from the sensors aboard the TRMM satellite and, subsequently, the A-Train constellation to produce a unique energy budget and water cycle dataset with the goal of addressing the key science hypothesis that the large-scale hydrologic cycle fundamentally varies in response to perturbations in the Earth's energy balance. The study involves activities that fall into three broad categories: (1) dataset production, (2) product evaluation, and (3) data analyses. First, the spatial and temporal structure of clouds, precipitation, radiative and latent heat fluxes, and a range of other atmospheric properties will be synthesized from a variety of different algorithms into a single, collocated product that greatly simplifies access and future processing for members of the climate community. Distinct approaches will be developed for application to the VIRS and TMI instruments aboard TRMM and the combination of MODIS, AMSR-E, and CPR that will fly in formation as part of the A-Train.

These datasets will be formulated with a view toward climate study applications and the evaluation of numerical models both of which require rigorous estimates of the associated uncertainties. All products will, therefore, be accompanied by an explicit error estimate that combines the impacts of errors in all observations with those incurred as a result of assumptions in the physical models required to extract the information they contain. For this purpose, we will use a combination of sensitivity studies and cross-validation with similar products to assess the uncertainty in each product and to separate its random and systematic components.

The resulting datasets will be used to examine linkages between atmospheric diabatic heating and the global water cycle with a view toward assessing the representativeness of the physical parameterizations used in numerical models. Functional relationships between key components of the global water cycle and energy balance and the manner in which these relationships depend upon spatial and temporal averaging scale will be quantified, primary forcings and responses in the climate system will be examined, and the role of radiative heating in the evolution of precipitating cloud systems in the mid-latitudes and tropics will be explored in a statistical sense.

Ultimately, the proposed research will contribute a unique dataset for untangling the complex interactions at the root of feedback processes among clouds, precipitation, and radiation on scales that can only be accessed via satellite. It is anticipated that the associated analyses will provide new insights into the role of such processes in global climate change.